

## **TWO-STEP SELF-MODULATING SCROLL COMPRESSOR**

### **BACKGROUND OF THE INVENTION**

[0001] This invention relates to a scroll compressor which self-modulates between high and low capacity based upon two distinct criteria.

[0002] Scroll compressors are becoming widely utilized in refrigerant compression applications. In a scroll compressor, a first scroll member has a base and a generally spiral wrap extending from the base. A second scroll member is held in a non-orbiting fashion relative to the first scroll member and has a wrap that interfits with a wrap from the first scroll member. The first scroll member is driven to orbit relative to the second, and the interfitting wraps define compression chambers for compressing an entrapped refrigerant.

[0003] It is a goal in modern compressor design to be able to provide at least two capacity levels. In some instances, such as when the cooling load on a refrigerant cycle is not particularly high, a lower capacity may be desirable. Less energy is used to compress a lesser amount of refrigerant in low capacity operations. Thus, various modulation schemes have been developed in the prior art.

[0004] In one modulation scheme, the compressor moves to low capacity operation when the pressure differential is low. The pressure differential is the delta (difference) of the discharge pressure to the suction pressure. When this quantity is low, there is some indication that lower capacity operation may be in order.

[0005] This prior art compressor performs adequately to provide low capacity operation when the compressor is utilized in an air conditioning cycle. However, it is also

desirable to use such compressors as part of a heat pump system. In a compressor that is utilized for both air conditioning and heat pump operation, there are times when a relatively low pressure differential is not indicative of a need for low capacity. In particular, if the suction pressure is also low, the compressor may be operating in heat pump mode, and high capacity operation would still be desirable. The prior art will still provide low capacity operation under those circumstances.

### **SUMMARY OF THE INVENTION**

[0006] In a disclosed embodiment of this invention, two distinct criteria are considered by the self-modulating capacity control. A first valve is operative to move between an open and closed position based upon the suction pressure. If the suction pressure is low, then the valve is maintained in the closed position, and high capacity operation occurs. A second valve is maintained in a closed position when the pressure differential is high. As long as either of these two conditions (low suction pressure or high pressure differential) are maintained, then high capacity operation occurs. However, if neither condition occurs, then both valves move to the open position and the compressor self-modulates to low capacity operation.

[0007] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] Figure 1 shows a capacity envelope.

**[0009]** Figure 2 is a cross-sectional view through a scroll compressor embodying the present invention.

**[0010]** Figure 3A shows a compressor control under conditions resulting in low capacity.

**[0011]** Figure 3B shows one condition wherein high capacity would still be maintained.

**[0012]** Figure 3C shows another high capacity condition.

**[0013]** Figure 3D shows yet another high capacity condition.

**[0014]** Figure 4 is a graph showing the conditions that will result in the four valve positions of Figures 3A-3D.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

**[0015]** Figure 1 shows a desired capacity envelope for a scroll compressor which could be utilized in both heat pump and air conditioning applications. As mentioned previously, the prior art does not have the low capacity condition confined only to the right side of the overall envelope. Instead, the top line *t* of the low capacity envelope, extended to the left as shown in dotted line with the prior art compressor. As mentioned above, the area to the left of the low capacity envelope shown in Figure 1 would desirably be maintained at high capacity operation at least during heat pump operation.

**[0016]** The compressor shown in Figure 2 achieves the envelope shown in Figure 1. The compressor 20 incorporates an orbiting scroll 22 orbiting relative to a non-orbiting scroll 24. An intermediate pressure dump 26 and an intermediate pressure tap 28 deliver refrigerant into a valve chamber associated with a valve 29. Valve 29 is responsive to overall

suction pressure. Suction pressure, as is known, is related by a multiplier to the intermediate pressure. A spring 32 drives the valve body 40 away from a valve stop 31 having a pin 34. As shown in Figure 2, suction pressure 36 leads to a tap 38 on a side of the valve body 40 that also includes the spring 32. Thus, suction pressure and the spring force drives the valve 40 to the right against the intermediate pressure force. As can be seen in Figure 2, the intermediate pressure passing through dump 26 moves into a passage 42. Thus, this intermediate pressure is delivered intermediate to enlarged portions 41 of the valve body 40. Since this intermediate pressure "sees" both portions 41, it does not effect the position of the valve body 40. However, as is also clear, the intermediate pressure through tap 28 passes into a chamber on the right side of the valve body 40, and its rightmost enlarged portion 41, and drives the valve body 40 to the left. As the suction pressure increases, the difference between the intermediate pressure and the suction pressure also increases, and eventually the position of the valve body 40 moves to that shown in Figure 2. As shown, the valve 40 includes a necked-down intermediate portion between the two enlarged portions 41.

[0017] A valve stop is identified by element 30, which stops the valve body 40 as it is driven to the right. As a worker of ordinary skill in the art would appreciate, the valve stop 30 is configured such that fluid can pass from the tap 28 into the chamber to the left of the valve stop 30, and against the rightmost of the enlarged portions 41.

[0018] A second valve 44 includes a piston 46 that sees discharge pressure on the left hand side from a discharge pressure chamber 47. A suction pressure tap 49 and an intermediate pressure tap 51 deliver refrigerant pressure into a chamber to the right hand side of the piston 46. This pressure fluid along with the spring force 52 tends to hold the piston 46 at the illustrated position against a piston stop 60. In Figure 2, both the valves 29 and 40 are

shown in the open position such that refrigerant can flow from the dump 26, into lines 42, 51, 49 and 38 back to suction 36. Thus, with the valves 29 and 44 in the position illustrated in Figure 2, low capacity operation is achieved. As can be appreciated from Figure 2, the refrigerant tap through line 42 is simply the refrigerant to be dumped under low capacity operation. Figure 3A shows this same low capacity operation. This is a condition wherein the suction pressure is above a particular amount and the pressure differential is below a particular amount. This is zone 1 of Figure 4. Under these conditions, low capacity operation is desirable.

[0019] As shown in Figure 3B, the pressure differential is now increased such that the discharge pressure to the left side of the piston 46 has overcome the force on the right side of the piston 46. Under these conditions, the piston 46 blocks the tap 49 and refrigerant is no longer bypassed. Thus, high capacity operation occurs. As shown in Figure 3B, the suction pressure is also low such that the valve body 40 has moved to the right blocking line 42. For this separate reason, high capacity operation will occur. As shown in Figure 4, this would be zone 2.

[0020] As shown in Figure 3C, the pressure differential is lower. However, the suction pressure is still sufficiently low that the valve 40 remains in a position blocking line 42. High capacity operation will still occur. This is zone 3 from Figure 4.

[0021] Figure 3D shows the condition wherein the pressure differential is sufficiently high to drive the piston 46 to the right, while the suction pressure is also sufficiently high such that the valve body 40 moves to the open position. Even so, since the piston 46 blocks flow through the line 49, high capacity operation still occurs. This is zone 4 from Figure 4.

**[0022]** In sum, the present invention discloses a simple system which requires two distinct conditions to occur before the compressor self-modulates to low capacity operation. Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.